AD-A133 432 ABRASION-EROSION RESISTANCE OF CONCRETE MADE WITH TWO AGGREGATES STONEWAL.. (U) ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG MS STRUC.. T C HOLLAND

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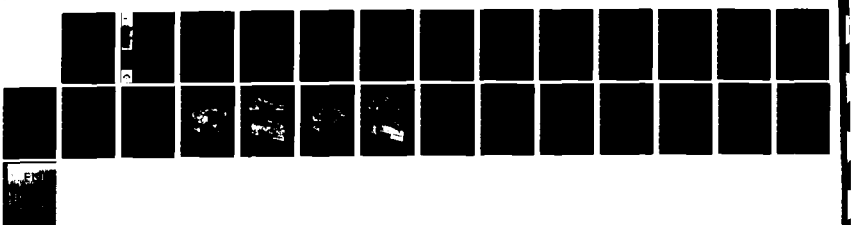

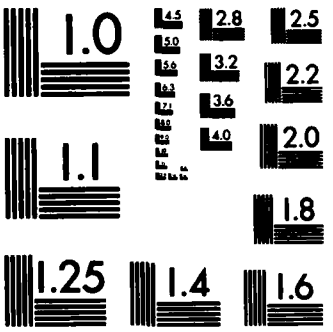

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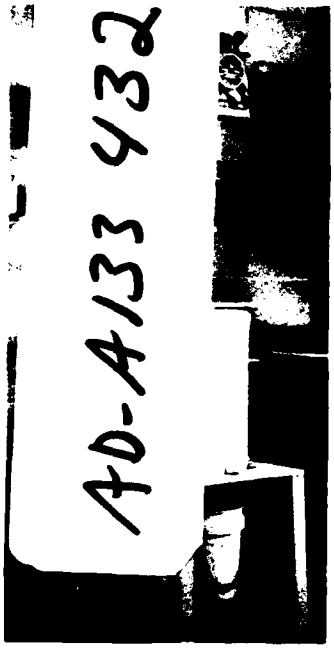

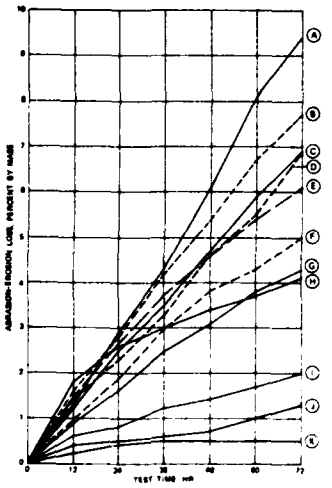

STRUCTURES LABORATORY

MISCELLANEOUS PAPER SL-83-15

ABRASION-EROSION RESISTANCE OF CONCRETE MADE WITH TWO AGGREGATES, STONEWALL JACKSON DAM, WEST VIRGINIA

by

Terence C. Holland

Structures Laboratory
U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Miss. 39180

September 1983
Final Report

Prepared for U. S. Army Engineer District, Pittsburgh
Pittsburgh, Pa. 15222

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Abrasion-erosion resistance (concrete)
Concrete properties
Stonewall Jackson Dam

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The resistance to abrasion-erosion of two concretes made with different coarse aggregates was evaluated. The aggregates used were selected as being representative of those that may be selected for use during construction of Stonewall Jackson Dam.

The two coarse aggregates were limestones from different sources. All other concrete ingredients were identical for the two mixtures. Both concretes

(Continued)

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20. ABSTRACT (Continued)

showed very high abrasion-erosion losses when tested using the Corps of Engineers standard test method.

A recommendation was made that coarse aggregates with better wear-resistant properties be selected for use in areas of the structure that may be subjected to abrasion-erosion.

PREFACE

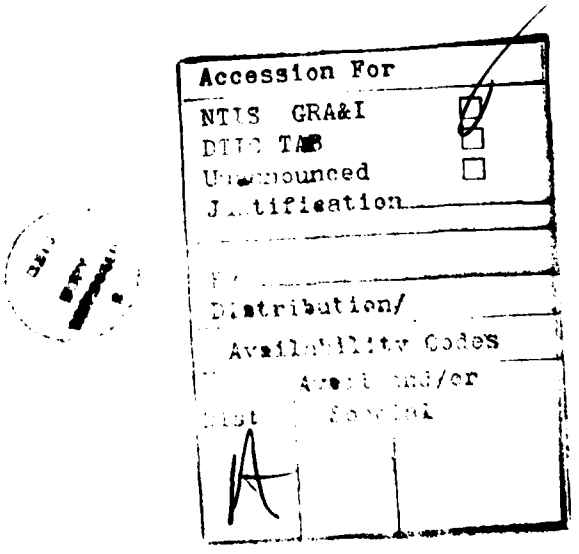
The investigation described in this report was conducted for the U. S. Army Engineer District, Pittsburgh, by the Concrete Technology Division (CTD) of the Structures Laboratory (SL), U. S. Army Engineer Waterways Experiment Station (WES). Authorization for this investigation was given by DA Form 2544, ORPED-83-34, dated 22 November 1982.

The investigation was performed under the general supervision of Mr. Bryant Mather, Chief, SL, and Mr. John M. Scanlon, Jr., Chief, CTD, and under the direct supervision of Dr. Terence C. Holland, who served as principal investigator. Mr. Steven A. Ragan prepared the concrete mixtures; Mr. Dale Glass, Mr. Frank W. Dorsey, and Mr. Roger Buttner conducted the abrasion-erosion tests. Mr. Stuart Long served as the point of contact at the Pittsburgh District. This report was prepared by Dr. Holland.

The information in this report was originally provided to the Pittsburgh District as an informal letter report (WESSC letter, "Abrasion-Erosion Resistance, Concrete Mixtures, Stonewall Jackson Dam," dated 10 February 1983).

Funds for publication of this report were provided from those made available for operation of the Concrete Technology Information Analysis Center (CTIAC). This is CTIAC Report No. 66.

Commander and Director of WES during this investigation and the preparation and publication of this report was COL Tilford C. Creel, CE. Technical Director was Mr. F. R. Brown.



CONTENTS

CONVERSION FACTORS, NON-SI to SI (METRIC)
UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
cubic feet	0.02831685	cubic metres
fluid ounces per cubic yard	38.6738	millilitres per cubic metre
fluid ounces per pound (mass)	65.1896	millilitres per kilogram
inches	25.4	millimetres
pounds (force) per square inch	0.006894757	megapascals
pounds (mass)	0.45359237	kilograms
pounds (mass) per cubic foot	16.01846	kilograms per cubic metre
pounds (mass) per cubic yard	0.5932764	kilograms per cubic metre

ABRASION-EROSION RESISTANCE OF CONCRETE MADE WITH TWO AGGREGATES, STONEWALL JACKSON DAM, WEST VIRGINIA

PART I: INTRODUCTION

Purpose

1. The purpose of this investigation was to evaluate two aggregates on the basis of resistance to abrasion-erosion of concrete made using them. These aggregates were selected by members of the Pittsburgh District staff as representative of aggregates that may be selected for use in construction of the Stonewall Jackson Dam.

Scope

2. This investigation was limited to testing concrete specimens made from mixtures containing the two subject aggregates. For purposes of comparison, data obtained during this study have been compared to that obtained during an abrasion-erosion study of concretes using various aggregates for a repair project at Kinzua Dam.*

Authority

3. The work described by this report was authorized by DA Form 2544, ORPED-83-34, dated 22 November 1982, from the Pittsburgh District.

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* Holland, Terence C. 1983. "Abrasion-Erosion Evaluation of Concrete Mixtures for Stilling Basin Repairs, Kinzua Dam, Pennsylvania," Miscellaneous Paper SL-83-16, U. S. Army Engineer Waterways Experiment Station (WES), Vicksburg, Miss.

PART II: TEST METHOD, MATERIALS, AND CONCRETE MIXTURES

Test Method

4. Abrasion-erosion testing was conducted in accordance with CRD-C 63-80,* "Test Method for Abrasion-Erosion Resistance of Concrete (Underwater Method)." This test procedure involves subjecting the concrete specimens to abrasion-erosion caused by the wear of steel grinding balls on the concrete surface. The steel grinding balls are propelled by water in the test chamber. The water is in turn propelled by a submerged mixer paddle. Test specimens are periodically removed from the apparatus to determine the amount of abrasion-erosion damage. The damage is quantified and reported as a percentage of original mass lost.

Materials

5. The primary materials involved in this investigation were the two coarse aggregates being evaluated. Except for the coarse aggregates, the materials used were the same as those used in the Kinzua test program. All materials used are described in the following paragraphs.

Fine aggregate

6. The fine aggregate, Structures Laboratory (SL) serial No. PITT-8 S-1, was from the Buffalo Slag Co., Franklinville, New York. This fine aggregate is classified as a glacial sand and is composed primarily of limestone and sandstone fragments. There was some clay present in the samples, but it was determined not to be a detrimental swelling clay. Test results for this aggregate (grading, specific gravity, and absorption) are given in Table 1.

7. This fine aggregate meets the grading requirements of ASTM C 33, "Standard Specification for Concrete Aggregates" (CRD-C 133),

* All CRD-C test methods are published in the Handbook for Concrete and Cement, U. S. Army Engineer Waterways Experiment Station, 1949 (with quarterly supplements), Vicksburg, Miss.

as well as both alternates for fine aggregate for concrete of the Civil Works guide specification.*

Coarse aggregates

8. The first coarse aggregate was a limestone produced by the Greer Limestone Company, Greer, West Virginia. This aggregate is described in the Concrete Materials Design Memorandum** (Appendix 2B) as containing "several types of limestone, varying from slightly to highly argillaceous in nature." Test data for this aggregate are presented in Table 2.

9. The Greer coarse aggregate as supplied by the Pittsburgh District meets the requirements of size No. 4 of ASTM C 33 (CRD-C 133). The small amount of material finer than 3/4 in.† resulted in a somewhat harsh concrete mixture that would not be acceptable for normal applications. This aggregate was washed before use.

10. The second coarse aggregate was a limestone produced by the J. F. Allen Company, Elkins, West Virginia. This aggregate is described in the Concrete Materials Design Memorandum (Appendix 2F) as containing "calcareous and silty argillaceous sandstones, several types of limestone, the majority of which are slightly to moderately argillaceous, and calcareous, sandy silty dolomite." Test data for this aggregate are presented in Table 2.

11. The Allen coarse aggregate as supplied by the Pittsburgh District meets the requirements of size No. 4 of ASTM C 33 (CRD-C 133). The small amount of material finer than 3/4 in. resulted in a somewhat harsh mixture that would not be acceptable for normal applications. This aggregate was washed before use.

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* Office of the Chief of Engineers. 1978. "Civil Works Construction Guide Specification: Concrete," CW-03305, Washington, D. C.

** U. S. Army Engineer District, Pittsburgh. 1982. "Stonewall Jackson Lake, West Fork River, West Virginia, Design Memorandum No. 11: Concrete Materials," Pittsburgh, Pa.

† A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 3.

Cement

12. The portland cement used, SL serial No. RC-888, was purchased from the Marquette Cement Co., Brandon, Mississippi. The cement meets the requirements of ASTM C 150 (CRD-C 201) for a Type I cement. The physical and chemical test results for the cement are presented in Table 3.

Admixtures

13. The air-entraining admixture used was Hunts Air-In, from laboratory stock. It is a neutralized vinsol resin produced by Hunt Process Corporation - Southern, Ridgeland, Mississippi.

Concrete Mixtures

14. Two concrete mixtures were proportioned for this investigation, one for each of the coarse aggregates. The mixtures were essentially the same as that used in the Kinzua investigation (Kinzua G1 mixture). The mixture proportions may be found in the table indicated:

a. Greer limestone: Table 4.

b. Allen limestone: Table 5.

PART III: TEST DATA AND DISCUSSION

Test Data

15. The properties for the fresh and hardened concretes are presented in Table 6. In addition to the data for the concretes containing the Greer and Allen aggregates, data from the Kinzua G1 concrete and from a chert aggregate concrete are included in the table for comparison.

16. The abrasion-erosion test data for the concretes containing the Greer and Allen coarse aggregates are presented in Tables 7 and 8, respectively. These data, along with that for the Kinzua G1 concrete and the chert aggregate concrete, are plotted in Figure 1.

17. Photographs of specimens, containing the Greer limestone, at the conclusion of testing are in Figure 2. Photographs of specimens, containing the Allen limestone, at the conclusion of testing are in Figure 3.

Discussion

18. Both aggregates tested showed relatively high abrasion-erosion losses. These results are in agreement with the results of earlier testing of limestone aggregates. As can be seen in Table 6, the two limestone aggregates tested did not perform as well as the chert aggregate, even though the compressive strength of the concrete containing the limestone aggregates was higher than that of the concrete containing the chert aggregate. This result is also in agreement with previous WES testing.

19. Both of the concretes containing the test aggregates showed apparently equal wear on the paste and aggregate portions. There is no evidence, for either type of aggregate, of aggregate particles being plucked from the matrix.

20. Of the two types of aggregate, the Greer limestone appears to be slightly more susceptible to abrasion-erosion loss.

21. Because of the gradings of the two coarse aggregates tested, the results of this testing may not be directly comparable to other work. No research has been accomplished to date on the effect of aggregate gradings on abrasion-erosion resistance. While grading may be assumed to have some influence on abrasion-erosion resistance, it is not likely to be a significant factor that would drastically change the results of the present abrasion-erosion test method. Specifically, had a greater percentage of material passing the 3/4-in. sieve been present for these two aggregates, it is doubtful that the results would have been significantly different.

PART IV: CONCLUSIONS AND RECOMMENDATIONS

22. Neither the Allen nor the Greer coarse aggregate appears to be well suited for use in conventional concretes in areas that may be subjected to severe abrasion-erosion forces during the lifetime of the planned structure. Since these two aggregates were selected as being representative of those available for use in the structure, it is doubtful that any of the available local aggregates will be suitable for use in areas susceptible to severe abrasion-erosion.

23. The District is encouraged to explore the use of other more wear-resistant coarse aggregates for use in areas that may be subjected to abrasion-erosion.

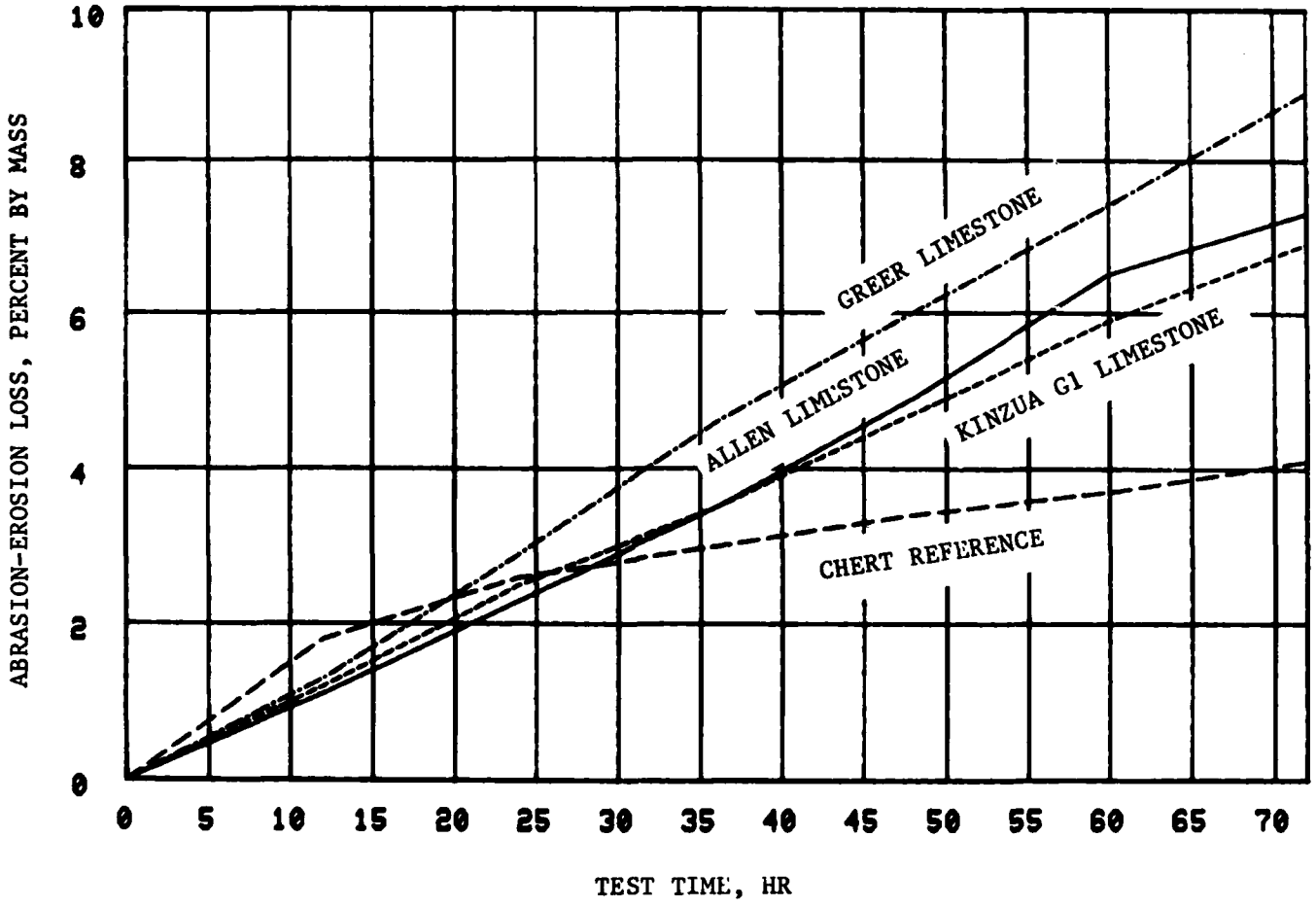

Figure 1. Comparison of abrasion-erosion resistance of concretes tested during this test program and two concretes tested previously

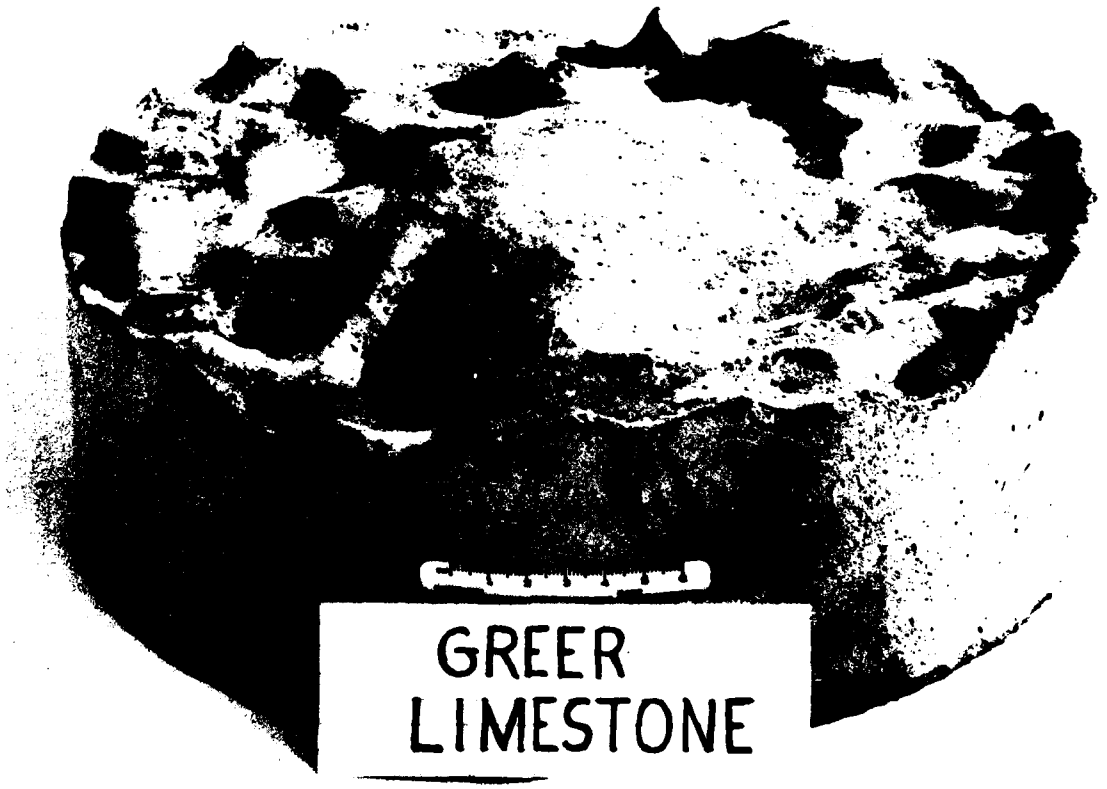

Figure 2. Posttest photographs of concrete specimens containing Greer limestone (Sheet 1 of 2)

Figure 2. (Sheet 2 of 2)

Figure 3. Posttest photographs of concrete specimens containing Allen limestone (Sheet 1 of 2)

Figure 3. (Sheet 2 of 2)

Table 1. Fine Aggregate Data.

STATE NY	INDEX NO.:	AGGREGATE DATA SHEET	TESTED BY: USAEWES
LAT	LONG		DATE 19 May 1982
LAB SYMBOL NO.: PITT-8 S-1			TYPE OF MATERIAL: Fine Aggregate
LOCATION: Franklin, NY			
PRODUCER: Buffalo Slag Co.			
SAMPLED BY: Pittsburgh District Personnel			
TESTED FOR: Kinzua Dam			
USED AT:			
PROCESSING BEFORE TESTING: None			
GEOLOGICAL FORMATION AND AGE:			

GRADING (CRD-C 103) (CUM. % PASSING):

SIEVE	3-6"	1½-3	¾-1½"	#4-¾"	FINE AGG.
6 IN.					
5 IN.					
4 IN.					
3 IN.					
2½ IN.					
2 IN.					
1½ IN.					
1 IN.					
¾ IN.					
½ IN.					
⅜ IN.					
NO. 4					100
NO. 8					93
NO. 16					71
NO. 30					47
NO. 50					20
NO. 100					7
NO. 200					2
-200[a]					0
F.M.[b]					2.62

(a) CRD-C 105 (b) CRD-C 104

TEST RESULTS

	3-6"	1½-3	¾-1½"	#4-¾"	FINE AGG.
BULK SP GR, S.S.D. (CRD-C 107, 108)					2.63
ABSORPTION, % (CRD-C 107, 108):					1.6
ORGANIC IMPURITIES, FIG. NO. (CRD-C 121)	———	———	———	———	
SOFT PARTICLES, % (CRD-C 130)					———
% LIGHTER THAN SP GR _____ (CRD-C 122)					
% FLAT AND ELONGATED (CRD-C 119, 120)					
WT AV % LOSS, 5 CYC $MgSO_4$ (CRD-C 115)					
L.A. ABRASION LOSS, % (CRD-C 117, 145) GRADING _____					
UNIT WT, LB/CU FT (CRD-C 106):					
FRIABLE PARTICLES, % (CRD-C 142)					
SPEC HEAT, BTU/LB/DEG F. (CRD-C 124)					
REACTIVITY WITH NaOH (CRD-C 128): Sc, MM/L.					
Rc, MM/L.					

MORTAR-MAKING PROPERTIES (CRD-C 116)

TYPE _____ CEMENT, RATIO: _____ DAYS, _____ %, _____ DAYS, _____ %

LINEAR THERMAL EXPANSION MILLIONTHS/DEG F. (CRD-C 125, 126):

ROCK TYPE	PARALLEL	ACROSS	ON	AVERAGE

MORTAR:

MORTAR-BAR EXPANSION AT 100F, % (CRD-C 123):

	FINE AGGREGATE				COARSE AGGREGATE			
	2 MO.	6 MO.	9 MO.	12 MO.	3 MO.	6 MO.	9 MO.	12 MO.
LOW-ALK. CEMENT: % Na_2O EQUIVALENT:								
HIGH-ALK. CEMENT: % Na_2O EQUIVALENT:								

SOUNDNESS IN CONCRETE (CRD-C 40, 114):	F&T	HW-CD	HD-CW
FINE AGG. COARSE AGG: DFE_{300}			
FINE AGG. COARSE AGG: DFE_{300}			

PETROGRAPHIC DATA (CRD-C 127):

Table 2

Coarse Aggregate Data

Sieve Size	Cumulative Percent Passing		
	CRD-C 133 Size No. 4	Allen	Greer
2 in.	100	100	100
1-1/2 in.	90-100	100	100
1 in.	20-55	37.6	33
3/4 in.	0-15	4.7	5.8
3/8 in.	0-5	0.8	0.3

	Allen		Greer	
	ORDL*	WES	ORDL*	WES
Specific Gravity CRD-C 107	2.67	2.68	2.70	2.70
Absorption CRD-C 107	0.9	0.7	0.5	0.4

* Data from Concrete Materials Design Memorandum.

Table 3. Cement Test Data.

TO: Structures Laboratory Research Group ATTN: Terry Holland	REPORT OF TESTS OF PORTLAND CEMENT RC-888	FROM: CORPS OF ENGINEERS U.S. ARMY Structures Laboratory Waterways Exp Station ATTN: Cem & Pozz Group P. O. Box 631 Vicksburg, MS 39180

TEST REPORT NO. WES-188-82	BIN NO.	CWT REPRESENTED:	DATE: 25 May 82
SPECIFICATION: ASTM C 150, Type I		DATE SAMPLED: 13 May 82	
COMPANY: Marquette Cement	LOCATION Brandon, MS	BRAND:	
THIS CEMENT DOES X MEET SPECIFICATION REQUIREMENTS			

SAMPLE NO.	1								
SiO_2, %	22.0								
Al_2O_3, %	3.7								
Fe_2O_3, %	2.9								
MgO, %	3.4								
SO_3, %	2.6								
LOSS ON IGNITION, %	1.0								
ALKALIES-TOTAL AS Na_2O, %	0.50								
Na_2O, %	0.07								
K_2O, %	0.66								
INSOLUBLE RESIDUE, %	0.16								
CaO, %	63.2								
C_3S, %	54								
C_3A, %	5								
C_2S, %	22								
$C_3A + C_3S$, %	59								
C_4AF, %	9								
$C_4AF + 2C_3A$, %	19								
HEAT OF HYDRATION, 7D, CAL/G									
HEAT OF HYDRATION, 28D, CAL/G									
SURFACE AREA, SQ CM/G (A.P.)	3680								
AIR CONTENT, %	10.1								
COMP. STRENGTH, 3 D, PSI	3310								
COMP. STRENGTH, 7 D, PSI	4015								
COMP. STRENGTH, 28 D, PSI	5150								
FALSE SET-PEN. F.I., %									
SAMPLE NO.	1								
AUTOCLAVE EXP., %	0.04								
INITIAL SET, HR/MIN	3:15								
FINAL SET, HR/MIN	5:30								
SAMPLE NO.									
AUTOCLAVE EXP., %									
INITIAL SET, HR/MIN									
FINAL SET, HR/MIN									

REMARKS: Job Number 441-S778.12SC41

CC: McDonald

Table 4. Mixture Proportions, Greer Limestone

REPORT OF SELECTION OF CONCRETE MIXTURE PROPORTIONS
(CRD-C 3)

PROJECT NAME: Stonewall Jackson Abrasion Testing	SYMBOL: / SERIAL NO.:	DATE: Dec 1982
CONCRETE REQUIRED FOR:		MIXTURE NO.:

MATERIALS

PORTLAND CEMENT, SS-C-192. TYPE: I ADDITIONS: BRAND AND MILL: Marquette	POZZOLON OR OTHER CEMENT: TYPE: None SOURCE:	AIR- ENT. ADMIXTURE: TYPE: Hunt Air-In AMOUNT[1]: 2.3 fl oz/yd^3

FINE AGGREGATE	COARSE AGGREGATE
TYPE: Glacier Sand SOURCE: Buffalo Slag Co. Franklinville, NY	TYPE: Limestone SIZE: SOURCE: Greer Limestone Co. Greer, WV

MATERIALS	SAMPLE SERIAL NO.	SIZE RANGE	COARSE AGGR (%)	BULK SP GR (SSD)	ABSORP %
PORTLAND CEMENT	RC-888				
•					
•					
FINE AGGREGATE	PITT-8 S-1	No. 4 - 200		2.63	1.6
COARSE AGGREGATE (A)	--	No. 4 - 1-1/2 in.		2.70	0.4
COARSE AGGREGATE (B)					
COARSE AGGREGATE (C)					
COARSE AGGREGATE (D)					

MIXTURE DATA				SPECIMEN DATA					
				CYLINDERS			BEAMS		
MATERIALS	MIX. BY WEIGHT	S. S. D. WEIGHTS ONE CU YD BATCH (LB)	SOLID VOL ONE CU YD (CU FT)	SIZE: NO.	AGE	PSI	SIZE: NO.	AGE	PSI
PORTLAND CEMENT	1.00	534.4	2.719						
• ** WRA									
•									
FINE AGGREGATE		1189.6	7.249						
COARSE AGGREGATE (A)		1992.8	11.828						
COARSE AGGREGATE (B)									
COARSE AGGREGATE (C)									
COARSE AGGREGATE (D)									
WATER		238.6	3.854						
AIR 5%			1.350						
TOTAL		3955.1	27.000						

W/C (WT): 0.45	S/A, % VOLUME: 38
SLUMP (IN.)[4]: 1-1/2	THEO. UNIT WT (LB/CU FT): 154.2
BLEEDING (%)[2]:	ACTUAL UNIT WT (LB/CU FT):
AIR CONTENT (%)[3]: 5.0	THEO. CEMENT FACT (LB/CU YD): 534.4
AIR CONTENT (%)[4]:	ACTUAL CEMENT FACT (LB/CU YD):

1 Calculated on the basis of:
2 Expressed as the percentage of mixing water separating from the concrete when tested by CRD-C 9.
3 In the entire batch as mixed.
4 In that portion of the concrete containing aggregate smaller than the 1-1/2-in. sieve.

* *For "other cement," pozzolan, second size of fine aggregate, as may be required.*

REMARKS: Condition of mix, workability, plasticity, bleeding, etc.

** WRA: Hunt HPS-R, 26.72 fl oz/yd^3 (5.0 fl oz/100 lb cement).

WES FORM NO. REV MAR 1972 583

Table 5. Mixture Proportions, Allen Limestone

REPORT OF SELECTION OF CONCRETE MIXTURE PROPORTIONS
(CRD-C 3)

PROJECT NAME: Stonewall Jackson Abrasion Testing	SYMBOL: / SERIAL NO.	DATE: Dec 1982
CONCRETE REQUIRED FOR:		MIXTURE NO

MATERIALS

PORTLAND CEMENT, SS-C-192, TYPE: I ADDITIONS: BRAND AND MILL: Marquette	POZZOLON OR OTHER CEMENT, TYPE: None SOURCE:	AIR ENT. ADMIXTURE TYPE: Hunt Air-In AMOUNT: 2.3 fl oz/yd^3

FINE AGGREGATE	COARSE AGGREGATE
TYPE: Glacier Sand SOURCE: Buffalo Slag Co. Franklinville, NY	TYPE: Limestone SIZE SOURCE: J. F. Allen Co. Elkins, WV

MATERIALS	SAMPLE SERIAL NO.	SIZE RANGE	COARSE AGGR (%)	BULK SP GR (SSD)	ABSORP
PORTLAND CEMENT	RC-888				
*					
*					
FINE AGGREGATE	PITT-8 S-1	No. 4 - 200		2.63	1.6
COARSE AGGREGATE (A)	--	No. 4 - 1-1/2 in.		2.68	0.7
COARSE AGGREGATE (B)					
COARSE AGGREGATE (C)					
COARSE AGGREGATE (D)					

MIXTURE DATA				SPECIMEN DATA					
				CYLINDERS			BEAMS		
MATERIALS	MIX. BY WEIGHT	S. S. D. WEIGHTS ONE CU YD BATCH (LB)	SOLID VOL ONE CU YD (CU FT)	SIZE: NO.	AGE	PSI	SIZE: NO.	AGE	PSI
PORTLAND CEMENT	1.00	534.4	2.719						
* **WRA									
*									
FINE AGGREGATE		1189.6	7.249						
COARSE AGGREGATE (A)		1978.0	11.828						
COARSE AGGREGATE (B)									
COARSE AGGREGATE (C)									
COARSE AGGREGATE (D)									
WATER		238.6	3.854						
AIR 5%			1.350						
TOTAL		3940.6	27.000						

W/C (WT): 0.45	S/A, % VOLUME: 38
SLUMP (IN.)[4]: 2	THEO. UNIT WT (LB/CU FT): 153.6
BLEEDING (%)[2]:	ACTUAL UNIT WT (LB/CU FT):
AIR CONTENT (%)[3]: 4.9	THEO. CEMENT FACT (LB/CU YD): 534.4
AIR CONTENT (%)[4]:	ACTUAL CEMENT FACT (LB/CU YD):

1 Calculated on the basis of:
2 Expressed as the percentage of mixing water separating from the concrete when tested by CRD-C 9.
3 In the entire batch as mixed.
4 In that portion of the concrete containing aggregate smaller than the 1-1/2-in. sieve.

* *For "other cement," pozzolan, second size of fine aggregate, as may be required.*

REMARKS: Condition of mix, workability, plasticity, bleeding, etc

** WRA: Hunt HPS-R, 26.72 fl oz/yd^3 (5.0 fl oz/100 lb cement).

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Table 6

Properties of Fresh and Hardened Concrete Mixtures Tested

Mixture	W/C (by Mass	Slump, in.	Air Content, %	Average Compressive Strength psi	Abrasion-Erosion Loss, % by Mass @ 72 hr
Chert Reference	0.45	3-1/2	5.3	4740	4.1
Kinzua G-1	0.45	2	5.1	5710	6.9
Stonewall Jackson: Allen limestone	0.45	2	4.9	5730	7.3
Stonewall Jackson: Greer limestone	0.45	1-1/2	5.0	5130	8.9

NOTES: (1) Average of three 6- by 12-in. specimens.
(2) Average of three abrasion-erosion specimens.

Table 7

Abrasion-Erosion Test Data

Concrete Mixture: Greer Limestone Aggregate

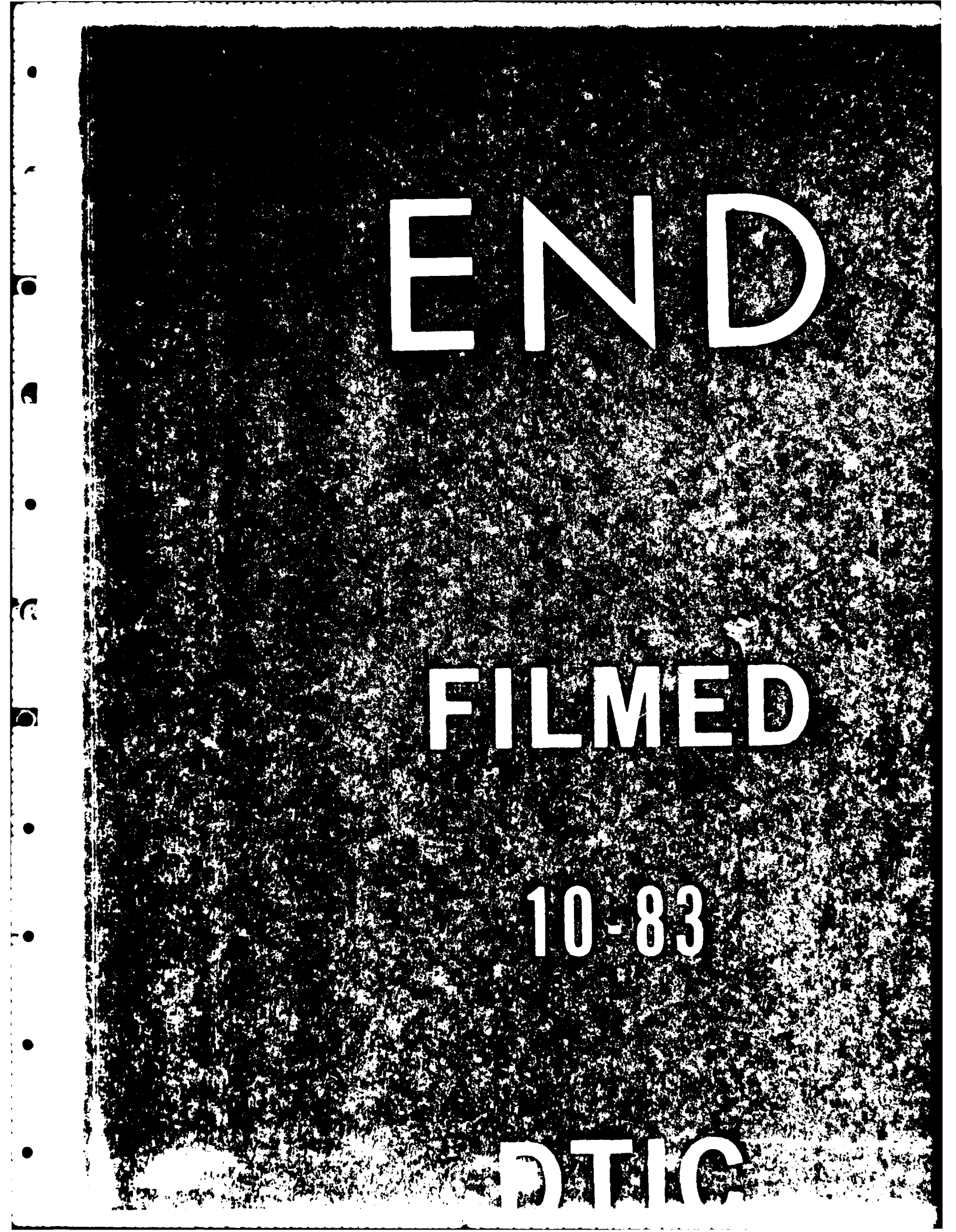
Elapsed Test Time hours	Specimen A Wt, lb	Specimen A Percent Loss	Specimen B Wt, lb	Specimen B Percent Loss	Specimen C Wt, lb	Specimen C Percent Loss	Average Percent Loss
0	38.00	0.0	38.15	0.0	38.15	0.0	0.0
12	37.45	1.4	37.60	1.4	37.70	1.2	1.3
24	36.95	2.8	37.05	2.9	36.95	3.1	2.9
36	36.15	4.9	36.50	4.3	36.40	4.6	4.6
48	35.75	5.9	35.90	5.9	35.80	6.2	6.0
60	35.35	7.0	35.30	7.5	35.20	7.7	7.4
72	34.80	8.4	34.80	8.9	34.55	9.4	8.9

Table 8

Abrasion-Erosion Test Data

Concrete Mixture: Allen Limestone Aggregate

Elapsed Test Time hours	Specimen A Wt, lb	Specimen A Percent Loss	Specimen B Wt, lb	Specimen B Percent Loss	Specimen C Wt, lb	Specimen C Percent Loss	Average Percent Loss
0	38.05	0.0	38.00	0.0	37.90	0.0	0.0
12	37.70	0.9	37.65	0.9	37.35	1.5	1.1
24	37.20	2.2	37.15	2.2	37.00	2.4	2.3
36	36.70	3.5	36.75	3.3	36.45	3.8	3.5
48	36.25	4.7	36.15	4.9	36.00	5.0	4.9
60	35.35	7.1	35.80	5.8	35.35	6.7	6.5
72	35.05	7.9	35.35	7.0	35.20	7.1	7.3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